no 3 missing not available
9/12/-6

VOL. I. JANUARY, 1917. No. 1

THE JOURNAL

OF

THE BOARD OF COMMISSIONERS

OF AGRICULTURE

PORTO RICO

SAN JUAN, P. R.
BUREAU OF SUPPLIES, PRINTING, AND TRANSPORTATION
1917

A LIST OF THE COCCIDAE OF PORTO RICO.

By Thomas H. Jones,

Formerly Entomologist of the Experiment Station of the Board of Commissioners of Agriculture of Porto Rico.

From time to time various entomological workers have published references to the *Coccidae* of Porto Rico, but the list of twenty-three species collected on the island in 1899 by Mr. August Busck is, so far as known to the writer, the only attempt ever made to enumerate the Porto Rican scale-insects. This list appeared in 1900 in Bulletin No. 22, new series, of the Division of Entomology, United States Department of Agriculture, the determinations having been made by Messrs. T. Pergande, T. D. A. Cockerell, and C. L. Marlatt. In connection with this list it is stated that only one coccid, *Aspidiotus destructor*, had been previously recorded from Porto Rico, this being in a reference in the *Canadian Entomologist* for 1895, the material having been taken by Mr. J. D. Hall in the city of San Juan.

Some of the *Coccidae* of the island, especially those attacking citrus trees, are referred to somewhat fully in the publications of the Porto Rico Agricultural Experiment Station. In these articles Messrs O. W. Barrett and W. V. Tower have treated the greatest number of species and given the most extended economic accounts.

Much attention has been given to the parasitic fungi attacking the scale-insects of citrus trees by the workers of the Porto Rico Insular Experiment Station. They have recommended the planting of windbreaks in orchard areas to furnish suitable conditions for the development of these fungi, which under favorable circumstances become very efficient enemies of the scale-insects. Mr. J. R. Johnston published in 1915 a bulletin on the entomogenous fungi of the island, and in it made several references to those attacking *Coccidae*. The insect parasites and predators of Porto Rican scale-insects have, on the other hand, received but little attention. Messrs. O. W. Barrett, F. S. Earle, and D. L. Van Dine mention parasites of *Lepidosaphes beckii, Saissetia hemisphaerica,* and *Aspidiotus sacchari,* respectively, but do not give their scientific names. Apparently the only insect enemies of the scale-insects specifically recorded from Porto Rico are *Aspidiotiphagus citrinus* and *Cocci-*

doxenus portoricensis. The former is mentioned in the following statement by Mr. E. K. Carnes, which appeared in the Monthly Bulletin of the State Commission of Horticulture of California, Vol. 1, No. 8, page 398. In connection with data on the introduction of beneficial insects into California, Mr. Carnes states: "From Prof. C. W. Hooker, Mayagüez, Porto Rico. First shipment: *Lepidosaphes beckii, Chrysomphalus aonidum. Aspidiotiphagus citrinus* issued in considerable numbers. Second shipment: same material. Very few *A. citrinus* issued." *Coccidoxenus portoricensis* was described by Mr. J. C. Crawford from "the wax scale," collected in San Juan by Mr. Tower.[1]

This scarcity of references would indicate—considering what has already been published on the scale-insects of the island—that this group has few insect enemies in Porto Rico. This, however, is not the case, parasitism of many species being common.

In the present paper the idea has been to list all the species previously recorded from the island, with the locality, host-plant, the name of the writer, and a reference to the publication from which the data is taken. Added to this are the names of the species not heretofore recorded from Porto Rico, as well as new host-plants and localities for those already known to be present. No attempt has been made to include those species mentioned by other writers by genus or common names only, and where no more definite locality than "West Indies," with reference to any species, is given in a publication, that species has been omitted. While no endeavor has been made to summarize what has already been done on the island on the life-histories of the various species, natural and artificial methods of control, etc., I believe the bibliography is quite complete and the reader will find much of interest in the publications mentioned.

The data now presented for the first time are taken from the notes and specimens in the collection formerly belonging to the Experiment Station of the Porto Rico Sugar Producers' Association, and now at the Experiment Station of the Board of Commissioners of Agriculture of Porto Rico. All of the specimens have been examined by Mr. E. R. Sasscer, formerly of the United States Bureau of Entomology, and now with the Federal Horticultural Board. The writer wishes especially to thank Mr. Sasscer for his kindness in making the determinations and reading over the manuscript. Without his assistance the publication of this list would not have been possible. I wish also to thank Mr. D. L. Van Dine, formerly

[1] Descriptions of New Hymenoptera, No. 6, No. 1979. From Proc. U. S. Nat. Mus. Vol. 45, pp. 241–260. May 22, 1913. pp. 248–249.

Entomologist of the Experiment Station of the Porto Rico Sugar Producers' Association, and Mr. J. R. Johnston, formerly Plant Pathologist of the same station. Both have collected a number of species and Mr. Johnston has made the determinations of many of the host-plants. Since the time of my leaving Porto Rico my successor, Mr. G. N. Wolcott, has added some data to the list. Mr. R. T. Cotton of the same station, and Mr. R. H. Van Zwaluwenburg, Entomologist of the Porto Rico Agricultural Experiment Station at Mayagüez, have also added a number of new records from recent determinations.

The system that has been followed in making up the bibliography may be explained as follows: After each reference to records of other writers in the text, one or more numbers will be found in parentheses. The first number refers to the number preceding the author's name in the "Bibliography," found at the end of the list. The number, or the numbers, that may follow the first number indicates the page, or pages, on which the particular reference will be found.

In preparing the list Mrs. Fernald's catalogue of the *Coccidae* of the world has been followed. Special effort has been made to give the correct Latin names of the host-plants with the heretofore unpublished notes. The local Spanish common names of plants, given in quotations, are from the "Flora Portoricensis," by Professor Ignatius Urban, and the paper by Cook and Collins, "Economic Plants of Porto Rico," published by the Smithsonian Institution.

SUBFAMILY *Monophlebinae.*

Icerya montserratensis Riley and Howard.

Mr. Busck collected it in 1899 "on orange, Mayagüez, January 20," and on the same host at Bayamón. (2–92.) Mr. Tower recorded it in 1908 on the orange. (16–38.) Taken at Santurce (near San Juan) on twigs and undersides of leaves of an undetermined tree; at Río Piedras on the undersides of leaves of "caimito," *Chrysophyllum argenteum* Jasq., and at Mayagüez on "maricao" (*Byrsonima spicata*), *Casearia sylvestris*, coconut palm (*Cocos nucifera*), "guamá" (*Inga laurina*), "guava" (*Inga vera*), "saman" (*Pithecolobium saman*), and guava or "guayaba" (*Psidium guajava*).

SUBFAMILY *Ortheziinae.*

Orthezia insignis Dougl.

Collected on an undetermined plant at Dorado, on *Eupatorium*

odoratum at Comerío, on Gignonia sp. and *Ipomoea tilliacea* at Río Piedras, and on Coleus sp., *Hamelia patens, Ipomoea fastigiata, Lactuca* sp. and *Lantana camara* at Mayagüez.

SUBFAMILY *Conchaspinae.*

Conchaspis angraeci Ckll.

Found on branches of an ornamental croton (*Codiaeum* sp.), in garden at Mameyes.

SUBFAMILY *Dactylopiinae.*

Asterolecanium aureum Bdv.

Taken by Mr. Busck on the leaves of "a fiber plant" in San Juan in 1899. (2–92.)

Asterolecanium bambusae Bdv.

Collected by Mr. Busck "on bamboo" at Bayamón and at Utuado. (2–92.) The writer has taken it on bamboo at Río Piedras.

Asterolecanium lanceolatum Green.

Taken on leaves of bamboo at Río Piedras.

Asterolecanium pustulans (Ckll.)

Mr. Busck took this species "on *Anona muricata*" at San Juan and "on some leguminous plant" at Guayama. (2–92.) Mr. Barrett reported it in 1904 on the fig (*Ficus carica*) at the Mayagüez Experiment Station (1–446) and Mrs. Fernald records it from Porto Rico. (6–52.) It has been found on "escoba" (*Sida antillensis*) and "jazmín" (*Jasminum sambac*) at Río Piedras by the writer, and on *Grevillea robusta, Castilloa* sp., and *Inga vera* at Mayagüez.

Phenacoccus gossypii Towns. and Ckll.

Collected "on cotton," Humacao, by Mr. Busck. Following the data there is the note, "New to the West Indies." (2–92.) In 1902 Mr. H. Maxwell-Lefrey, in an article on scale-insects of the West Indies, gave "Porto Rico" after *Phenacoccus helianthi* var. *gossypii.* (14–298.)

Pseudococcus calceolariae (Mask.).

Mr. E. E. Green, the well-known authority on *Coccidae,* after examining specimens of sugar-cane mealy-bugs sent him from Río

Piedras, stated that they "agreed exactly with examples of *Pseudococcus calceolariae* Mask.," his determination being based "upon comparison with typical examples received from the late Mr. Maskell himself." (12–461.) Mr. Johnston records the fungus, *Aspergillus flavus,* as occurring on this mealy-bug in Porto Rico. (11–14.)

Pseudococcus citri (Risso.).

Mr. Barrett mentioned this mealy-bug (as *Dactylopius citri*) in 1904 as an enemy of citrus stock with the note, "is not common." (1–445.) Mr. Tower has published concerning it as a pineapple pest (20) and Dr. C. W. Hooker mentioned its occurrence in coffee plantations. (10–35, 37.)[1]

I have taken specimens of a mealy-bug, which Mr. Sasscer states is close to *Pseudococcus citri,* on the roots of three plants at Río Piedras. They were as follows: celery (*Apium graveolens*), corn or "maíz" (*Zea mays*), and a grass, probably *Sporobolus jacquemontii.*

Pseudococcus nipae (Mask.).

This is probably the most omniverous mealy-bug on the island. It has been collected as follows: on coconut palm (*Cocos nucifera*), Santurce; on guava or "guayaba" (*Psidium guajava*), on *Anthurium acaule,* on sour-sop or "guanábano" (*Anona muricata*), on "caimito" (*Chrysophyllum argenteum*), and on *Musa paradisiaca* var.,[2] Río Piedras; on sea grape or "uvero" (*Coccoloba uvifera*) and on "aguacate" (*Persea gratissima*) at Naguabo.

According to Mr. Johnston, the fungi, *Cephalosporium lecanii* and *Empusa fresenii,* occur on this mealy-bug. (11–19, 21.)

Pseudococcus sacchari (Ckll.).

Mealy-bugs are important pests of sugar cane in Porto Rico and practically all previous references regarding them are listed under this species. Listed as *Dactylopius sacchari,* it was taken by Mr. Busck "on sugar cane" at Bayamón, Mayagüez, and at Humacao in 1899 (2–92), and it is recorded by Mrs. Fernald from Porto Rico. (6–109.) Mr. Van Dine published references to its occurrence on

[1] Doctor Hooker stated that the ant, *Myrmelachista ambigua ramulorum* Wheeler, feeds on the honey-dew secreted by this mealy-bug. What is more interesting, however, is the accompanying statement made by Doctor Hooker, regarding the connection between this ant and "a large, fleshy, pink scale of the subfamily Coccinae, probably as yet undescribed." He observed that these Coccids "are carried by the ants into canals eaten out along the pith of the smaller new growth which will bear the next season's fruit. The growth is thus weakened to such an extent that when bent down by the pickers at the next harvest it breaks easily." Much of the coffee is thus lost.

[2] I have not tried to distinguish between the varieties of *Musa paradisiaca,* commonly known in English as bananas and plantains and in Spanish as "guineos" and "plátanos."

the island in 1911 (21–18, 29), 1912 (22–19, 20), and 1913 (23–251, 252, 253, 255, 256). (24–31.)

Dr. E. P. Felt has described a cecidomyiid, *Karschomyia cocci* (5–304), the larvae of which were taken by Mr. Van Dine in colonies of *Pseudococcus sacchari* (?) on sugar cane.

Chaetococcus bambusae (Mask.).

Collected on "Bamboo" at Mayagüez.

SUBFAMILY *Coccinae*.

Pulvinaria psidii Mask.

This species is often very abundant on the "jobo" tree. Mr. Tower reported it on orange and coffee. (16–38.)

We have taken it as follows: On mango (*Mangifera indica*), Río Piedras; on guava or "guayaba" (*Psidium guajava*), Río Piedras and Luquillo; on hog plum or "jobo" (*Spondias lutea*), Arroyo and Río Piedras; on a tree, *Rauwolfia tetraphylla*, Ponce.

Ceroplastes ceriferus (Anderson).

Collected on "almacigo" (*Elaphrium simaruba*) at Santa Rita, near Guánica, and on "yerba de San Martín" (*Sauvagesia erecta*) at Naguabo.

Ceroplastes cirripediformis Comst.

Found on an undetermined plant at Algarrobo.

Ceroplastes floridensis Comst.

Taken by Mr. Busck "on *Anona reticulata*." (2–92.) Mr. Barrett records it in 1904 as an enemy of citrus stock (1–445) and Mr. Tower in 1908 reported it "on the rose and orange." (16–38.) It has also been taken on *Rapanea guianensis* and *Ficus laevigata* at Río Piedras and on guava or "guayaba" (*Psidium guajava*) and mango (*Mangifera indica*) at Mayagüez.

Vinsonia stellifera (Westw.).

This interesting scale, the so-called "star-scale," is often present on the leaves of the rose apple, mango, and coconut. Mr. Busck took it on the latter host at "Catana" (probably a misspelling of Cataño) and Arroyo. (2–92.) Later, in 1904, it is mentioned by Mr. Barrett as occurring "commonly on the coconut" (1–447), and

the following statement by the same author may refer to this species, "An undetermined scale (Vinsonia?) occurs on the rose apple (*Jambos jambos*)." (1–446.)

It has further been taken as follows: On coconut palm (*Cocos nucifera*) Santurce; on "pomarrosa" or rose apple (*Jambos jambos*), Río Piedras and Mameyes; on mango (*Mangifera indica*), Santa Isabel; on *Agave sisalana, Musa* sp. and on guava or "guayaba" (*Psidium guajava*) at Mayagüez.

Inglisia vitrea Ckll.

On West Indian pigeon pea or "gandul" (*Cajanus indicas*) at Mameyes and at Comerío; on "achiote" (*Bixa orellana*) at Río Piedras.

Coccus hesperidum (Linn.).

Collected on "maguey" (*Agave sisalana*), at Río Piedras.

Coccus mangiferae (Green).

Collected on leaves of "pomarrosa" or rose apple (*Jambos jambos*) at Río Piedras; on mango (*Mangifera indica*) and *Cinnamomum zeylanicum* at Mayagüez. A fungus (*Cephalosporium lecanii*) is mentioned by Mr. Johnston as being common on this scale. (11–19.)

Saissetia hemisphaerica (Targ.).

A very comon species. Mr. Busck took it in 1899 as follows, the species being recorded as *Lecanium hemisphaericum:* "On eggplant, Catana, January 10." (2–92.) Mr. Barrett records it (as *Lecanium hemisphaericum*) on coffee, on "guanábano" (*Anona muricata*), on cassava, and states that it is "probably the most common scale on the orange here." (1–444, 445, 446, 447.) In the same year, 1904, Mr. Earle reported this species (as *Lecanium hemisphaericum*) as occurring on the orange and also wrote that a "Lecanium (probably *L. hemisphaericum*) is also at times abundant and destructive" to coffee. (4–458, 459, 463.) In 1906 Mr. van Leenhoff, Jr., mentioned *Saissetia hemisphaerica* as an enemy of coffee. (25–46.) Mr. Tower wrote of its injuries to citrus trees in 1907 (15–26), 1908 (16–32), 1909 (17–23) and 1911 (19–15). The writer has recorded it from eggplant. (13–4.)

The following records are to be added: On "jasmin" (*Gardenia jasminoides*), the introduced pepper tree (*Schinus molle*), rose apple or "pomarrosa" (*Jambos jambos*), a cultivated shrub (*Graptophyllum pictum*), and alligator pear or "aguacate" (*Persea gratis-*

sima), Río piedras; on "marunguey" (*Zamia integrifolia*), Vega Alta; on *Sida* sp., on black nightshade or "mata-gallinas" (*Solanum nigrum* var. *americanum*), and on guava or "guayaba" (*Psidium guajava*), Luquillo; on coffee or "café" (*Coffea arabica*), and *Thunbergia erecta,* Mameyes; on "orozuz" or "pascueta" (*Leptilon canadense*), Ciales; on *Rauwolfia tetraphylla,* Ponce; on *Antigonon leptopus, Drypetes glauca,* and *Solanum seaforthianum* at Mayagüez.

Mr. Johnston records a fungus (*Cephalosporium lecanii*) as occurring on this scale. (11–19.)

Saissetia nigra (Nietn.).

Taken by Mr. Busck in 1899 as follows, being recorded as *Lecanium nigrum:* "On *Terminalia catappa,* San Juan, January 5. On cotton, San Juan, January 5 (var. *depressum* Targ.)." (2–92.) In Mrs. Fernald's catalogue this species is recorded from Porto Rico. (6–204, 205.)

Collected in addition as follows: On "anamú" or "cadillo pequeque" (*Pavonia typhalea*), Canóvanas; on cotton or "algodón" (*Gossypium barbadense*), Guánica; on China berry or "lilaila" (*Melia azedarach*), Fortuna (near Ponce); on the introduced pepper tree (*Schinus molle*), Río Piedras; on black nightshade or "mata-gallinas" or "yerba mora" (*Solanum nigrum* var. *americanum*), on *Sida* sp., and on China berry (*Melia azedarach*), Luquillo; on *Euphorbia sanguinea* at Mayagüez.

Doctor Howard has determined as *Arrhenophagus chinonaspidis* Auriv. a parasite reared from material on which *Saissetia nigra* and *Hemichionaspis minor* were present.

Saissetia oleae (Bern.).

In 1899 Mr. Busck took this species "on Calabassa tree, Lares, January 25. On honey locust, Adjuntas, January 30. On *Guazuma ulmifolia,* Guayama, February 4. On *Terminalia catappa,* Mayagüez, January 20." The genus is given as *Lecanium.* (2–92.)

Mr. Johnston collected *Saissetia oleae* on "madre de cacao" (*Erythrina glauca*) at Río Piedras, and it has been taken by the writer on "almendra" (*Terminalia catappa*) at Guánica. It has also been taken on orange oleander (*Nerium oleander*) and "berengena cimarrona" (*Solanum torvum*) at Mayagüez.

Aclerda tokionis (Ckll.).

Collected on stalk of sugar cane at Río Piedras.

SUBFAMILY *Diaspinae*.

Chionaspis citri Comst.

This species is one of the most injurious scale-insect pests of the citrus groves in Porto Rico. It was collected by Mr. Busck in 1899 "on lime" at Añasco (2–93) and is probably generally distributed over the island. It has been treated by Messrs. Barrett (1–445), Henricksen (8–27) and Tower (17–24, 25) (19–14, 15) in various publications of the Porto Rico Agricultural Experiment Station as an enemy of citrus trees.

Doctor Howard has determined a parasite reared by the writer from *Chionaspis citri* as *Aspidiotiphagus citrinus* (Craw.).

Howardia biclavis (Comst.).

Collected by Mr. Busck "on *Bixa orellana*" at San Sebastián and Añasco. (2–93.) I have taken it on the same host, which is known as "achiote," "achote," and "annato," at Río Piedras, and in addition it has been collected as follows: On "caimito" (*Chrysophyllum cainito*), and "mamey" (*Mammea americana*), Mameyes; on "algarrobo" (*Hymenaea courbaril*), on *Casearia arborea*, on silver oak, an introduced tree (*Grevillea robusta*), and on West Indian pigeon pea or "gandul" (*Cajanus indicus*), Río Piedras; on "palo de cucubano" (*Guettarda scabra*) and *Cordia* sp., Dorado; on "roble" (*Tecoma pentaphylla*) and *Acalypha wilkesiana* at Naguabo; on sapodilla or "níspero" (*Achras sapota*), *Coffea arabica*, *Doryalis cafra*, and *Plumiera rubra* at Mayagüez.

Diaspis echinocacti (Bouché.).

Mrs. Fernald records this species from Porto Rico. As food-plants in the various countries, where it occurs, the following are given: *Opuntia ficus-indica*, *Echinocactus ottonis*, *E. tenuispinus*, etc. (6–229, 230.) Mr. Busck lists *Diaspis calyptroides* Costa var. *opuntiae* Ckll. as having been collected at Ponce. (2–93.)

Aulacaspis pentagona (Targ.).

As is true elsewhere where it occurs, this coccid has a long list of food-plants in Porto Rico. Among cultivated plants the "papaya" or papaw suffers especially from its attacks.

In 1899 Mr. Busck took it "on castor-oil plant, Río Piedros (perhaps a misspelling of Río Piedras), January 17. On unknown tree, Bayamón, January 16. On peach, Adjunctas (probably Ad-

juntas), January 24. On honey locust, January 30. On mahagua, Fajardo, February 17." (2–93.) Mr. Earle in 1904 reported that it "occurs very commonly on the orange, as well as on various other trees and plants" (4–458) and that a scale, probably this species, was "killing a great many of the (papaw) trees." (4–467.) Mr. Barrett in the same year wrote, "very destructive to peach trees in the east part of the island; this species also attacks mulberry and papaw." (1–446.) In 1907 Mr. Tower stated, "very abundant all over the island, infesting peach, plum, mulberry, papaw, castor bean and other plants." (15–27.) The writer has recorded it from okra and pepper. (13–4.)

It has also been taken as follows: On willow (*Salix* sp.), Ponce; on "bruja" (*Bryophyllum pinnatum?*), Comerío; on "papaya" (*Carica papaya*), on West Indian pigeon pea or "gandul" (*Cajanus indicus*), Río Piedras; on "majagua" (*Paritium tiliaceum*), Mameyes; on "cadillo" (*Urena lobata*), Dorado; on castor bean or "higuerete" (*Ricinus communis*), Ciales; on "mamey" (*Mammea americana*) at Naguabo; on okra, *Hyptis* sp., *Solanum torrum, Trema micrantha,* and *Acalypha wilkesiana* at Río Piedras; on *Mangifera indica, Erythrina* sp. and oleander (*Nerium oleander*) at Mayagüez; on "emajagua" (*Paritium tiliaceum*), Adjuntas, and on cassava (*Manihot utilissima*) at Añasco.

Hemichionaspis aspidistrae (Sign.).

Collected on leaves of fern (*Nephrolepsis exaltata* var. *bostoniensis*), at Río Piedras.

Hemichionaspis minor (Mask.).

A common species, sometimes found in company with *Saissetia nigra* (Nietn.), and *S. hemisphaerica* (Targ.). Taken by Mr. Busck "on eggplant, Catana, January 17. On *Guazuma ulmifolia,* Guayama, February 4" in 1899, being listed as *Chionaspis* (*Hemichionaspis*) *minor.* (2–93.) The writer has also recorded it from eggplant. (13–4.)

It has been taken as follows: On cotton or "algodón" (*Gossypium barbadense*), Guánica; on China berry or "lilaila" (*Melia azedarach*), Fortuna (near Ponce); on "yerba rosario" (*Aeschynomene sensitiva*) and ornamental croton (*Codiaeum* sp.), Naguabo; on "verbena" (*Valerianodes jamaicensis*), Río Piedras; on "berengena cimarrona" (*Solanum torvum*) and "cadillo" (*Triumfetta semitriloba*), Luquillo; on *Lantana involucrata* at Mameyes; on *Asparagus spengleri* and "saman" (*Pithecolobium saman*) at Mayagüez.

Doctor Howard has determined as *Arrhenophagus chionaspidis* a parasite reared from material on which *Hemichionaspis minor* and *Saissetia nigra* were present.

Pinnaspis buxi (Bouché.).

Collected on leaves of a tree epiphyte belonging to the family *Bromeliaceae* at Mameyes; on *Philodendron* sp., Ciales; on "corozo" palm (*Acrocomia media*) and another palm (*Areca lutescens*) at Río Piedras.

Leucaspis indica Mar.

Collected on mango (*Mangifera indica*) at Mayagüez.

Aspidiotus cyanophylii Sign.

On a blue gum (*Eucalyptus* sp.) at Naguabo.

Aspidiotus destructor Sign.

Apparently the first scale-insect recorded from Porto Rico, this species is very common, especially on the undersides of the leaves of coconut palms. It is often so abundant on the older leaves of these palms that they turn yellow and die. It was first recorded in the Canadian Entomologist for 1895, page 261, by Mr. T. D. A. Cockerell, the specimens having been collected in San Juan by Mr. J. D. Hall. Mr. Busck took it "on banana leaves" at "Catana," and on the same host at San Juan and Arroyo. (2–93.) Mr. Barrett in 1904 stated that at Ponce many of the coconut trees were "dead or dying from attacks" of this coccid. (1–447.)

Mr. Van Dine collected *Aspidiotus destructor* from coconut palm (*Cocos nucifera*) at Santurce, and it has further been collected as follows: On silk oak (*Grevillea robusta*), on guava or "guayaba" (*Psidium guajava*), on *Musa paradisiaca* var., Río Piedras; on alligator pear or "aguacate" (*Persea gratissima*), Mameyes and Guayama; alligator apple (*Anona palustris*) and *Mammea americana*, Río Piedras; and on date palm (*Phoenix dactylifera*), Mayagüez.

Dr. Howard has examined a parasite reared from this scale by the writer and states that it "is apparently my *Aphedinus diaspidis*."

Aspidiotus forbesi Johnson.

Listed by Mrs. Fernald as occurring in Porto Rico and fifteen food-plants are given for the species in the countries where it is

known to occur. With the possible exception of "Jasmine," no tropical plants are included in the list. (6–259, 260.)

Aspidiotus lataniae Sign.

Collected on *Castilla* sp. at Mayagüez.

Aspidiotus sacchari Ckll.

Mentioned by Mr. Van Dine in 1911 (21–19, 31), 1912 (22–22) and 1913 (23–251, 257) (24–34) as occurring on sugar cane. It is a common but not serious enemy of this host. Mr. Van Dine has collected it at Guánica, Fortuna (near Ponce), Fajardo, and Canóvanas, and in addition it has been collected at Río Piedras and Humacao, all collections having been made from sugar cane. According to Mr. Hood, Mr. Sasscer stated that it occurred with *Odonaspis* sp. which I took on the stalks of para grass or "malojillo" (*Panicum barbinode*) at Guánica. (9–70.)

Pseudaonidia tesserata (de Charm.).

From garden rose at Mameyes.

Selanaspidus articulatus (Morg.).

Collected by Mr. Busck "on orange leaves, El Yunque, February 18; about 2,000 feet altitude" in 1899. (2–93.) Has been mentioned by Mr. Barrett (1–445) and Mr. Tower (16–38) as an enemy of citrus trees. Mr. Tower, in 1909, stated that "*Pseudaonidia articulatus*" was "causing a little trouble" as an orange pest. (17–25.)

Taken by the writer on rose apple or "pomarrosa" (*Jambos jambos*) leaves at Río Piedras and on a blue gum (*Eucalyptus* sp.) at Naguabo. It has also been taken on *Anona muricata* and *Ficus nitida*, at Río Piedras.

Chrysomphalus aonidum (Linn.).

A serious enemy of citrus trees. In the publications of the Porto Rico Agricultural Experiment Station its occurrence on the island, fungi parasitic to it, and methods for its control have been discussed by Messrs. Earle (as *Aspidiotus ficus*) (4–459), Barrett (1–445), Henricksen (as *Chrysomphalus ficus*) (8–27) and Tower. (15–25, 26) (16–32) (17–24) (19–14, 15.) With the exception of the last reference, Mr. Tower mentions this scale as *Chrysomphalus ficus*.

It was collected by Mr. Busck in 1899 on *Terminalia catappa*, San Juan; on *Anona muricata*, San Juan; on oleander, Ponce; and

on *Musa*, Caguas. (2–93.) Mr. Carnes mentions having received it from Porto Rico. (3–398.) It has also been taken on *Ficus nitida* at Río Piedras and an sisal hemp (*Agava sisalana*) at Mayagüez.

Chrysomphalus aurantii (Mask.).

Mr. Busck took this species in 1899 "on *Anona muricata*, San Juan," and on the same host at Ponce. (2–93.) In 1904 M. Barrett reported it as an enemy of citrus stock, with the note, "rare but apparently spreading." (1–445.)

Chrysomphalus biformis (Ckll.).

On "maya" (*Bromelia pinguin*) at Mameyes; on *Agave sisalana* and "aguacate" at Río Piedras; on mango (*Mangifera indica*), Río Piedras, and on a cycad (*Cycas revoluta*), at Naguabo.

Chrysomphalus dictyospermi (Morg.).

On mango (*Mangifera indica*), at Río Piedras, and on a cycad (*Cycas revoluta*), at Naguabo.

Chrysomphalus personatus (Comst.).

Mr. Busck collected it "on plantain leaves, Caguas, January 11. On *Anona muricata*, San Juan, January 5. On banana leaves, Catana, February 21. On coconut palm, Mayagües, January 20; Caguas, January 11." (2–93.) On coconut palm (*Cocos nucifera*), Santurce; on rose apple or "pomarrosa" (*Jambos jambos*), Río Piedras; on mango (*Mangifera indica*), Santa Isabel; on leaves of a tree (*Ficus* sp.) and on "mamey" (*Mammea americana*), Mameyes; and on a blue gum (*Eucalyptus* sp.) at Naguabo.

Pseudischnaspis bowreyi (Ckll.).

Collected on asparagus fern at Mayagüez.

Pseudoparlatoria ostreata Ckll.

Collected on *Solanum scaforthianum and Acalypha* sp. at Mayagüez.

Lepidosaphes beckii (Newm.).

This species has been more often mentioned as a pest of citrus orchards than any other scale-insect. The following workers have discussed it in the bulletins and annual reports of the Porto Rico

Agricultural Experiment Station: Messrs. Earle (4–457, 458), Barrett (1–445), Henricksen (7–401, 402) (8–27) and Tower (15–26) (16–32, 33) (17–23, 24) (18–24, 25) (19–13, 15). In Messrs. Earle's and Barrett's articles and in the first article by Mr. Henricksen the species is given as *Mytilaspis citricola.* Mr. Carnes, of California, mentions having received *Lepidosaphes beckii* in shipments of material from Porto Rico, from which it was hoped to introduce scale-insect parasites into that State. (3–398.) Mr. Johnson records the fungi, *Myriangium duriaei* and *Sphaerostilbe coccophila,* from this scale. (11–28, 29.)

The species was taken on ornamental croton (*Codiaeum* sp.) at Río Piedras by the writer.

Lepidosaphes lasianthi (Green).

Collected on leaves of croton (*Croton humilis*) at Río Piedras.

Ischnaspis longirostris (Sign.).

Taken by Mr. Busck "on coconut palm, Caguas, January 11; Catania (probably misspelling for Cataño), January 12; Mayagüez, January 20; Arroyo, February 3." (2–93.) Taken by the writer at Naguabo on *Citharexylum fructicosm.* It has also been taken on *Ixora ferrea, Asparagus spengleri* and *Acrocomia media at* Río Piedras.

BIBLIOGRAPHY.

1. Barrett, O. W.—Report of Entomologist and Botanist. Ann. Rpt. P. R. Agric. Exp. Sta. for 1903. Ann. Rpt. Office of Exp. Stas. for year ending June 30, 1903. U. S. Dept. Agric. 1904. pp. 429–450.

2. Busck, A.—Notes on a brief trip to Puerto Rico in January and February, 1899. Bul. 22, new series, Div. Ent., U. S. Dept. Agric. 1900. pp. 88–93. Includes a list of *Coccidae* collected by Mr. Busck in Porto Rico, the determinations having been made by Messrs. T. Pergande, T. D. A. Cockerell and C. L. Marlatt.

3. Carnes, E. K.—Report of Insectary Division for Month of May, 1912. Monthly Bulletin State Commission of Horticulture, Sacramento, California. Vol. 1, No. 8, 1912. pp. 395–400.

4. Earle, F. S.—Report on Observations in Porto Rico. Ann. Rpt. P. R. Agric. Exp. Sta. for 1903. Ann. Rpt. Office of Exp. Stas. for year ending June 30, 1903. U. S. Dept. of Agric. 1904. pp. 454–468.

5. Felt, E. P.—Three New Gall Midges. Canadian Ent., Vol. XLV, No. 9. 1913. pp. 304–308.

6. Fernald, Mrs. M. E.—Catalogue of the Coccidae of the World. Bul. 88, Mass. Agric. Exp. Sta. 1903.

7. Henricksen, H. C.—Report of Assistant Horticulturist. Ann. Rpt. P. R. Agric. Exp. Sta. for 1904. Ann. Rpt. Office of Exp. Stas. for year ending June 30, 1904. U. S. Dept. Agric. 1905. pp. 399–406.

8. Henricksen, H. C.—Report of the Horticulturist. Rpt. on Agric. Investigations in P. R., 1905. Bul. 171, Office of Exp. Stas., U. S. Dept. Agric. 1906. pp. 23–41.

9. Hood, J. D.—Two New Thysanoptera from Porto Rico. Insecutor Inscitiae Menstruus, Vol. 1, No. 6, June, 1913. pp. 65–70.

10. Hooker, C. W.—Report of the Entomologist. Ann. Rpt. P. R. Agric. Exp. Sta. for 1912. 1913. pp. 34–38.

11. Johnston, J. R.—The Entomogenous Fungi of Porto Rico. Bul. 10, P. R. Brd. Commrs. Agric. 1915. pp. 33, fig. 1, plates 9.

12. Jones, T. H.—Additional Notes on Porto Rican Sugar-Cane Insects. Journ. Econ. Ent., Vol. 7, No. 6, 1914. pp. 461–463.

13. Jones, T. H.—Insects Affecting Vegetable Crops in Porto Rico. Bul. 192, U. S. Dept. of Agric. 1915. pp. 11, plates 4.

14. Maxwell-Lefroy, H.—Scale-Insects of the West Indies. West Indian Bul., Vol. III, No. 4, 1902. pp. 295–319.

15. Tower, W. V.—Report of the Entomologist and Plant Pathologist. Ann. Report of the P. R. Agric. Exp. Sta. for 1906. 1907. pp. 25–28.

16. Tower, W. V.—Report of the Entomologist and Plant Pathologist. Ann. Rpt. P. R. Agric. Exp. Sta. for 1907. 1908. pp. 31–38.

17. Tower, W. V.—Report of the Entomologist. Ann. Rpt. P. R. Agric. Exp. Sta. for 1908. 1909. pp. 23–28.

18. Tower, W. V.—Report of the Entomologist. Ann. Rpt. P. R. Agric. Exp. Sta. for 1909. 1910. pp. 24–28.

19. Tower, W. V.—Insects Injurious to Citrus Fruits and Methods for Combating Them. Bul. 10, P. R. Agric. Exp. Sta. 1911. pp. 35, plates 5.

20. Tower, W. V.—Control of the Brown Ant (*Solenopsis geminata* Fabr.) and the Mealy Bug (*Pseudococcus citri* Risso) in Pineapple Plantations. Circ. 7, P. R. Agric. Exp. Sta. p. 3.

21. Van Dine, D. L.—Report of the Entomologist. Bul. 1 (1st Rpt.), Exp. Sta. of P. R. Sugar Producers' Assoc. 1911. pp. 17–31.

22. Van Dine, D. L.—Report of the Entomologist. 2d Ann. Rpt.

(Bul. 2), Exp. Sta. of P. R. Sugar Producers' Assoc. 1912. pp. 15–22.

23. Van Dine, D. L.—The Insects Affecting Sugar Cane in Porto Rico. Journ. Econ. Ent., Vol. 6, No. 2. 1913. pp. 251–257.

24. Van Dine, D. L.—Report of the Entomologist. 3d Ann. Rpt. (Bul. 5), Exp. Sta. of P. R. Sugar Producers' Assoc. 1913. pp. 25–46.

25. Van Leenhoff, J. W.—Report of the Coffee Specialist. Rpt. on Agric. Investigations in P. R., 1905. Bul. 171, Office of Exp. Stas., U. S. Dept. Agric. 1906. pp. 42–47.

HISTORY AND CAUSE OF THE RIND DISEASE OF SUGAR CANE.

By JOHN R. JOHNSTON,

Formerly Pathologist of the Insular Experiment Station.

Introduction.

The rind disease of sugar cane has been one of the most widely discussed of all the cane diseases. It has been variously considered by some as being a harmless saprophyte and by others as having caused great damage in the cane fields. Chiefly owing to inaccurate and incomplete observations, literature on the subject is almost hopelessly confused as to the real nature of the fungus or the disease caused by it. That cane fields are still invaded by a serious disease of the rind which is always accompanied by a destruction of the tissues and a deterioration of the sugar content, render it important to ascertain the cause of the trouble. It is believed that a careful study of the literature in the light of numerous field and laboratory investigations will do much to clear up this subject. The writer has been studying the matter for the past three years and can come to no other conclusion than that the rind disease causes a great loss in many cane fields. When the nature of this disease is described and its history is shown, it is believed that this conclusion will be justified.

EXTERNAL APPEARANCE OF THE RIND DISEASE.

So confused is the literature on this subject that it will make the discussion clearer to state once for all that the rind disease is considered primarily a disease of the rind of the cane. Whatever effect there is upon other parts of the cane is considered secondary in ascertaining the cause of the trouble, although it may as a matter of fact be primary in the point of time in the life history of the fungus itself.

The external symptoms of the rind disease are primarily the appearance of numerous black pustules breaking through the rind of the cane. (See Plate I.) From these pustules oozes a coherent mass of spores which on exposure to the dry air hardens somewhat in the form of a stalk, varying in size and form from patelloid to subclavate or cylindrical, up to 1 or 2 mm. in length. Sometimes they appear merely as numerous tiny black threads breaking through the rind. When these black pustules appear, the tissues of the cane itself are already discolored and diseased. The relations of other symptoms of disease are complicated with the presence of other fungi and will be left to a fuller discussion further on. It will be noted that there are a few eruptions on the rind that are caused by different fungi. These will all be discussed in their proper place. The preceding brief diagnosis of rind disease will be used as a basis for discussing the history and full nature of the fungus and the disease caused by it.

THE AUTHOR'S INVESTIGATIONS OF THE RIND DISEASE.

FIELD NOTES IN PORTO RICO.

Conditions under which the rind fungus have been noted in Porto Rico are extremely variable. It has never been observed in fields of young green cane excepting in shoots injured or killed by some other fungus such as *Marasmius sacchari* or by such insects as the changa, the whitegrub, the root weevil, or the moth stalk-borer. In such cases it can hardly be considered more than a saprophyte.

In cane over six or eight months old this fungus can almost invariably be found on the leaf-sheaths of the cane, not universal on all stalks, nor on all varieties, but at least common in the cane

fields of Porto Rico. The fungus occurs not only at the base on the outside of the leaf-sheath, but occasionally near the joint of the leaf-sheath with the leaf-blade. On the leaf-sheaths, the fungus may hasten the drying of the leaf, but does not necessarily pass from the sheath into the stalk. Numerous canes have been observed up to maturity which had remained perfectly healthy so far as the stalk was concerned, but which had had the fungus on the leaf-sheaths for some months.

In contrast with the conditions found in green cane, in mature or almost mature cane considerable damage has been observed which appeared to be attributable to this fungus.

In Naguabo in 1912 a certain field of D625 presented an excellent growth. The planting was wide, *i. e.*, 7 feet between rows, but the stalks had developed well. Before the cane was considered quite ripe enough for cutting, it began to appear diseased, *i. e.*, black pustules appeared on the rind, the canes appeared water-soaked, and the tops died. In some cases moth borers were present, but with this exception there appeared no fungus in any quantity except the rind fungus *Melanconium sacchari*. In a few weeks' time this disease had spread over the field, not affecting all stalks, but some stalks in many stools. The loss in weight and sucrose before the cane could be cut was considerable.

Near Río Grande in 1912 was a field of a large yellow Demerara cane, probably D625 or D116, supposed by some to be identical canes. The growth of the cane at twelve months was excellent, consisting of an abundance of large stalks. It was generally known that this cane contained a comparatively small amount of sucrose especially on low wet soils such as in this case. It was suggested that possibly leaving the cane over for another season would produce a larger sugar content, therefore the canes were left for a period of twenty months. Long before this time had passed many of the stalks had become infected with the rind disease and become entirely rotted down, so that at the end of the period the field was almost an entire loss.

In the same vicinity in 1912 fields of the striped (*rayada*) and the native white cane (*Otaheite*), which were only twelve months old, behaved in the way.

This latter condition of cane twelve to fourteen months old rotting back with the rind fungus is not uncommon in Porto Rico. The moth stalk-borer is often associated with the fungus, but is no more common in diseased fields than in those not diseased. The conditions under which this disease occurs are not clear, but everything points

to a weakness in the cane due either to a weak soil or to drought or to excessive water. Apparently a variety of these conditions brings about much the same effect in cane.

Aside from the occurrence of the rind fungus in large mature canes, it is not uncommon to find it abundant in fields of cane that have been stunted through the presence of root disease, or some untoward soil condition. This is especially true in old ratoons that are running down. In Canóvanas in 1912 an entire field of cane failed to grow large and vigorous and before maturity almost the entire field was infected with this fungus and was a complete loss. In adjacent fields first crops have been obtained, but there, too, the ratoon crops have been lost in the same way.

In all cases in Porto Rico an infection with the rind fungus seems to be preceded by a weakening of the vitality of the cane through some other untoward condition. It happens, however, that these conditions cannot always be foreseen, and therefore the rind fungus must be considered a serious obstacle to the best results among the sugar planters. These various untoward conditions in themselves do not begin to have the effect that they do together with the rind fungus.

Cane may suffer from root disease, but does not rot out unless affected by the rind fungus also.

Cane may suffer from drought, but it does not deteriorate unless attacked by the rind fungus in addition.

Cane may suffer from floods, but that does not render it worthless as does a severe infection of the rind fungus.

Altogether the field investigations appear to demonstrate that *Melanconium sacchari* is capable of doing great damage in mature canes in Porto Rico.

INOCULATIONS WITH THE RIND FUNGUS.

Inoculations with pure cultures of the rind fungus have been made into green canes and into almost mature canes, but in no case was there any visible infection. In all these inoculations the cane was vigorous and the inoculating wounds were slight. This would tend to show that vigorous cane was not infected by this disease. No inoculating experiments have been made on weak canes.

FIELD INVESTIGATIONS IN SANTO DOMINGO.

Examination of the cane fields at La Romana, San Pedro de Macorís, and Santo Domingo city show the rind fungus to be common but not doing much damage. It is present only in canes which have

been seriously injured, *i. e.*, when the top has been cut off, and in these cases the infection has spread only to the first node, leaving the base of the cane perfectly sound.

INVESTIGATIONS IN THE SOUTHERN UNITED STATES.

Investigation here revealed quite the same conditions as in Santo Domingo; *i. e.*, no entire rotting of sound canes, but mere infection at the point of some serious injury and on the leaf-sheaths.

INVESTIGATIONS IN CUBA.

No extensive investigations have been made here by the writer of this paper, but stalks completely rotted by the rind fungus have been observed in the vicinity of Nipe Bay.

GREENHOUSE INVESTIGATIONS, WASHINGTON, D. C.

In the greenhouses in Washington, D. C., cane has been grown to a greater or less extent for the last seven or eight years. It has been common to find large stalks completely rotted out by this fungus. It is to be expected from our observations of the behavior of this organism that this would occur. Cane grown in the greenhouse is not as hardy as that grown out of doors; its roots are apt to be confined and the tops are subject to injury. Altogether the appearance of this disease in Washington corresponds well with the condition frequently found in Porto Rico and as casually observed in one place in Cuba, but not with its appearance as seen in Santo Domingo or the Southern United States.

It may thus be expected that there will be found a similar variation in the conditions in other countries which might to a large extent account for the variation in opinions regarding the importance of the rind fungus.

In the particular cases cited the possibility of confusing the case with infection by other fungi has been avoided by special search for such as *Colletotrichum falcatum*, so while there is no direct proof by inoculation that *Melanconium sacchari* causes the trouble under all conditions, there is the fairly satisfactory proof of it, arrived at by the process of elimination.

HISTORY AND IDENTITY OF THE RIND FUNGUS.

The first available description of a fungus breaking through the rind of the cane is that of *Strumella sacchari* by Cooke in Grevillea,

Vol. XIX, p. 45. He described this fungus from a specimen of sugar cane labeled Bailey 871 from Queensland, as follows:

"Pustules gregarious, erumpent, black, patelloid or subclavate, with a short stemlike base, or cylindrical multiform (½ mm. diam.), hyphae short, hyaline, simple; conidia cycindrically elliptical, continuous, pale fuscous, 10–12 x 3 microns." This description is purely one of the fungus and does not indicate the symptoms of the disease other than to say that the pustules are erumpent.

In 1878 Cooke published a description (8)[1] of one of Berkeley's species as follows:

Darluca Melaspora Berk. in litt. Pustulis prominulis, nigris, sporis oblongis binucleatis, cirrhis nigris. .015 x .115 mm. From sugar cane in Australia.

In 1892 was published a new species by Ellis and Everhart in a paper by Cockerell (7). The name of the new fungus was *Trullula sacchari* and its description as follows:

Acervuli innate-erumpent or entirely black, conicglobose, ⅓ to ½ mm. diam., resembling perethecia. Conidia catenulate, forming at first a continuous, hyaline filament, 70–75 microns long, soon separating into oblong 2–3 nucleate, olivaceous conidia, 8–11 x 2½–3 microns, rounded at the ends, and closely resembling the sporidia of some *Hypoxylon*. The chains of conidia are densely crowded and simple. The erumpent acervuli blacken the surface of the culm with the discharged conidia, but some of the acervuli are entirely buried in the inner substance of the culm and are apparently never erumpent. Found in Jamaica, Barbados and Trinidad on sugar cane.

In 1893 Massee (26) described the black erumpent fungus on sugar cane as a Melanconium stage of *Trichosphaeria sacchari*. In a later paper (27) he gave the succession of these various stages as follows: from Melanconium stage to macro- and micro-conidial stages and thence to the ascigerous stage which he called *Trichosphaeria sacchari*. His work was based on material received from Trinidad and other English colonies.

Fawcett (14) in 1894 wrote that he found *Trichosphaeria sacchari* (the Melanconium stage) present in Jamaica, but he found other diseased material, which he sent to Kew and which was examined by Massee and pronounced *Colletotrichum falcatum*. Later he wrote (15) that he found *Trichosphaeria* (Melanconium stage) and that Massee considered it only a form of *Colletotrichum falcatum*.

In 1895 Saccardo (32) changed the name of Cooke's *Darluca melaspora* to *Coniothyrium melasporum*. In the same year Prillieux and Delacroix (31) studied material from Mauritius which showed the same black erumpent fungus on the cane as did *Darluca* and

[1] Figures in parenthesis refer to bibliography at the end of the article.

Melanconium and the others. They called the fungus *Coniothyrium melasporum* following Saccardo's name, as they believed their fungus to be identical with *Darluca melaspora.*

Thistleton-Dyer (34) published a summary of the cane diseases in Barbados, in which he reiterates the statement that at Kew *Colletotrichum falcatum* Went is considered merely as one phase in the life history of *Trichosphaeria sacchari.* It should be noted that it was not claimed that *Colletotrichum falcatum* was the same as any other stage of *Trichosphaeria,* for from its appearance there could be no confusion as to that. It was stated that *Colletotrichum* was considered a stage in the life history of *Trichosphaeria.* There was, however, no proof brought forward to support this claim and subsequently the idea was given up. At present they are believed by investigators in general to be distinct fungi.

Went (39) published in 1896, in an article on sugar-cane diseases, criticisms of Massee's work on *Trichosphaeria,* together with the statement that Massee's macro- and micro-spores of *Trichosphaeria* were remarkably like the macro- and micro-spores of Went's *Thielaviopsis ethaceticus.* Went's opinion was strengthened by examination of West Indian material. He also found *Melanconium* spores in Java and from pure cultures obtained both the *Melanconium* spores and macrospores. Thistleton-Dyer (l. c.) believed Went's *Melanconium* was not really the *Melanconium sacchari* of the West Indies.

Massee (l. c.) had claimed that *Thielaviopsis* was the same as his macro- and micro-spores of *Trichosphaeria,* thus agreeing on this point with Went except that the latter did not connect them with the perfect stage of *Trichosphaeria.*

Prillieux and Delacroix (l. c.) agreed with Massee in considering *Thielaviopsis ethaceticus* to represent the macro- and micro-spore condition of the *Melanconium* fungus which they called *Coniothyrium.*

Finally in the history of the rind disease Howard issues a paper (19) in which he shows that *Colletotrichum falcatum* and *Melanconium* are not stages of the same fungus, but he claims that the former is the cause of the rind disease and not the latter. As Howard has made a most unfortunate confusion between cause and effect here, it will be necessary to discuss the matter more fully.

In preceding pages of this paper there was given a description of the fungus causing the rind disease and producing those symptoms commonly recognized as belonging to the rind disease, *i. e.,* numerous eruptions of the rind from which issue black masses of spores. As to whether this disease causes further destruction of the

tissues or as to whether there are other fungi that cause the destruction of the rind or of other tissues, that matter has not been discussed. The description of *Colletotrichum falcatum* as given by Went is as follows:

> Setis nunc seriatis, nunc in psuedo-conceptaculum, congregatis, cuspidatis, 100–200 x 4, conidiis falcatis, 25 x 4, hyalinis, ad basim setulorum, basidiis ovoideis, 20 x 8, hyalinis vel fuscis, suffultis.

Went found the fungus on living cane, but most of the reports definitely state that while the vegetative hyphae are common on living cane, fruiting bodies are very rare except on dead cane. Such being the case, it is not clear how *Colletotrichum falcatum* produces any eruptions on the rind. As to whether it does cause a serious disease of the cane is entirely a different matter.

From the foregoing descriptions it will be seen that five different names have been given to black erumpent fungi on sugar cane, *Strumella sacchari, Darluca melaspora, Trullula sacchari, Melanconium sacchari* and *Coniothyrium melasporum,* the last being admittedly the same as Darluca. It will be desirable to ascertain if all these names may apply to one and the same fungus. It must first be stated that the common fungus producing these black eruptions on cane throughout the West Indies, Hawaii, Mauritius, Natal, Australia, and other places appears to be one and the same and to be correctly classed as *Melanconium sacchari.* More rarely are found similar forms which might be mistaken for *Melanconium.* It will be desirable to review the descriptions of the fungi already mentioned in order to judge whether they may be considered to be *Melanconium* or distinct fungi.

1. *Strumella sacchari.*—Said by Thistleton-Dyer (35) to be the same as *Melanconium sacchari. Strumella* belongs in the *Tuberculariaceae,* quite a distinct group from that containing *Melanconium.* There is nothing in the description to indicate that the fungus is a true *Strumella* or that it cannot go in *Melanconium.* In fact, investigators seem agreed that these two names really belong to one and the same fungus.

2. *Darluca melaspora.*—Massee (28) states that this species is founded on material sent to Berkeley in 1878 from Porto Rico and not from Australia as stated by Cooke. Furthermore he states that the material itself shows the fungus to be a *Diplodia* and not a *Darluca.* It would seem that Massee's examination ought to settle the question, but it is not clear how Cooke's description of *Darluca melaspora* can apply to a *Diplodia.* Rather does it resemble *Melanconium* with the one-celled binucleate spores, 12 x 5 microns, and

black threads. To what the "cirrhis nigris" or "black threads" applies is not evident whether to pustules or to spores, but in neither case it would apply to a *Diplodia*. It would seem more likely that there were both forms in the material or that the material had been mislabeled. It would appear that Cooke's *Darluca melaspora* is really *Melanconium sacchari*.

3. *Trullula sacchari*.—This fungus has been said by Massee (27) to be similar to the macroconidial stage of *Trichosphaeria sacchari*. However, Massee evidently did not note that while his macroconidia measure 18–20 x 12 microns, the spores of *Trullula* measure 8–11 x 2½–3 microns, too great a difference to permit of their being considered as identical. It is possible that *Trullula sacchari* corresponds to the microconidia of *Trichosphaeria sacchari*, especially as the general description answers fairly well for it. Thus "conidia catenulate, forming at first a continuous, hyaline filament, 70–75 microns long, soon separating into oblong 2–3 nucleate, olivaceous conidia," answers fairly well for either fungus. However, "Acervuli innate erumpent or entirely black, conic-globose, ⅓–½ mm. dia. resembling perethecia" does not apply to the microconidia stage of *Trichosphaeria* but to the Melanconium stage. To no other known fungi does this description apply, and as the material is reported from at least three islands it is believed that the description was meant for one of the common cane fungi, *i. e.*, *Melanconium*, and possibly mixed with the microconidial stage of *Trichosphaeria*.

4. *Melanconium sacchari* described by Massee is placed in its proper genus. Massee, however, believed that he found also other stages of the same fungus. The perfect stage he called *Trichosphaeria sacchari*. This work will be discussed fully further on. It is sufficient to state here that *Melanconium sacchari* is the generally accepted name for the common erumpent black fungus found on the rind of sugar cane in many countries.

5. *Coniothyrium sacchari*.—This is Saccardo's name for *Darluca melaspora*, which has already been shown to be in all probability identical with *Melanconium sacchari*. Massee (l. c.) states that Prillieux and Delacroix in their paper (l. c.) have fallen into an error in considering *Melanconium* the same as *Coniothyrium*. They described material from Mauritius as *Coniothyrium sacchari* and illustrated their description with a plate. The illustration leaves little doubt that the material was *Melanconium*, and the description answers fully as well for *Darluca*. Apparently these are all one and the same fungus.

In summing up it is seen that—

Strumella sacchari is generally admitted to be identical with *Melanconium sacchari.*

Darluca melaspora is said to be a *Diplodia,* but really appears to be *Melanconium sacchari.*

Trullula sacchari is said to be identical with the macroconidial stage of *Trichosphaeria* but appears to be the same as *Melanconium sacchari.*

Melanconium sacchari is the generally accepted and proper name for the rind fungus of sugar cane.

Coniothyrium melasporum, same as *Darluca melaspora,* is probably *Melanconium sacchari.*

LIFE HISTORY OF THE FUNGUS.

In the foregoing paragraphs there has been given brief mention of various references to the so-called rind fungus as it has been understood by various investigators. In the main *Melanconium sacchari* and its various possible forms are considered the cause of the disease and will be treated as such.

Melanconium sacchari, the ordinary form of the rind disease, consists of dark septate hyphae running within the stalk of the cane. Immediately below the epidermis the hyphae often forms a layer of pseudo tissue from which arise the short conidiophores bearing the terminal conidia. These are produced in large numbers and if their formation is close to the surface of the epidermis, the mass breaks through and oozes out either forming a black conical heap or a long slender thread entirely made up of the spores. The variation in this formation apparently depends upon the rapidity of the formation of the spore mass, which in turn depends upon the moisture conditions in the atmosphere. These spores germinate and are supposed to grow into the cane and after increasing vegetatively to repeat the spore formation. The method of entrance through the rind of the cane is not positively known. It may be through the stomata, or through such wounds as those caused by the stalk-weevil, the moth borer or the ambrosia beetle, or there is the bare possibility that the hyphae can penetrate the cells of the epidermis itself.

There has been much discussion as to whether this fungus does not produce more than one kind of spore—that is to say, have more than one stage of growth. It is common for some fungi to have various stages of growth, and it is of the utmost importance to know them all in order to work out control measures for the disease. As

already mentioned the first description of *Strumella sacchari,* which has been identified with *Melanconium sacchari,* describes only the Melanconium form. Massee was the first to claim that he had found more than one stage, *i. e.,* a macroconidial and a microconidial stage in addition to the Melanconium stage. In his paper on the subject he attempted to prove the genetic connection between the forms. Massee placed four conidia (Melanconium [?] spores) in each of three flasks containing equal quantities of sugar-cane solution, and then placed the cultures for incubation in a temperature of about 75° F. At the end of five days the liquid in each of the flanks presented an opalescent appearance which examination showed to be due to very delicate, much branched hyphae. Examination of the contents of a second flask after eight days' growth showed numerous filaments of mycelium measuring up to 8 microns in diameter and full of brilliant, fine-grained, homogeneous protoplasm. These thick hyphae originated as lateral branches from the delicate hyphae first produced by the conidia.

A third flask after twelve days' growth assumed a dark olive color and the entire surface of the mycelium at the level of the solution presented an appearance of an olive-colored, dense, velvety mass. The velvety appearance proved to be due to the presence of closely packed, erect, dark olive conidiophores growing out into the air, each bearing at its apex a single chain of reddish-brown conidia—called by Massee microconidia. The dark olive color of the mass of mycelium immersed in the fluid was found to be due to immense numbers of large conidia arranged in chains and springing from the tips of the thick hyphae previously described. These latter forms Massee-called macroconidia.

It must be observed that Massee's method of procedure is not sufficiently described in detail to demonstrate clearly the origin of these various spores. He starts with four of the Melanconium spores placed in each of three flasks, but nothing is indicated to show that there might not have been some contamination. The first two flasks were treated after examination so that their contents were killed. As a result he found the microspore and the macrospores only in the third flask.

After the above experiment in which he is assumed to have produced from Melanconium spores two other forms in flasks, Massee took small portions of cane containing hyphae of Melanconium and placed them in a nutrient solution. The characters which distinguish Melanconium hyphae from others are not given, nor is it stated that there were no other hyphae present, nor is the operation stated

to have been done under sterile conditions. After twelve days the nutrient solution was crowded with mycelium bearing both forms of conidia, that is, the micro- and the macrospores. Further Massee took internal portions of diseased cane near the apex and placed them in a nutrient solution, care being taken to prevent the accidental introduction of other fungi. There resulted rapid growth of the hyphae and eventual formation of macroconidia.

An inoculation experiment was next carried out by introducing Melanconium conidia upon the base of an old leaf-sheath of cane six feet high. After twenty days Melanconium spores were produced. At the same time a small portion of diseased cane containing hyphae of the Melanconium stage were introduced into a slit made into a cane stalk. Mature fruit burst out of the cane after twenty-two days. Eight days later this cane was split open and it was found that at the joint where inoculation was performed by wounding the cane, the mycelium had produced the large macroconidia in the decaying tissue. No macroconidia were present at the point where infection took place through a dead-leaf base.

An inoculation experiment was made by placing the macroconidia on the basal part of the upper surface of a very young leaf; in five days the infected area became a deep red, and in fourteen days a dense pile of conidiophores appeared on the surface bearing microconidia. Internal macroconidia were not found. Nothing was said by Massee about the presence of Melanconium spores.

Another inoculation was made by placing macroconidia on the broken surface of a lateral shoot which had been broken off close to the stem. In fourteen days microconidia were formed, but no macroconidia, and no mention is made of Melanconium spores.

Two more experiments showed practically the same results, the macroconidia, however, being found in one case.

An inoculation made with microconidia produced both the micro- and macroconidia but no Melanconium spores.

Neither Massee's flask cultures nor his inoculation experiments can be taken as any proof that the Melanconium spores are in any way connected with either the micro- or macrospore forms.

Massee found two mature perithecia on a much decayed portion of a cane received from Barbados; they sprang from a point that had previously borne a crop of microconidia and were surrounded by old collapsed conidiophores, the conidia having disappeared. Massee says "although the evidence in favor of a genetic connection between the perithecia found on the cane and the microconidia with which they were associated, was strong, yet it could not be accepted

as conclusive; and it was not until similar perithecia were accidentally discovered on the surface of the material contained in one of the flask cultures, that this supposition was proved to be correct." The flask referred to was one filled with a mass of hyphae produced from a macroconidium. The submerged portion was black from a copious development of macroconidia, while the surface was covered with a dense pile of conidiophores bearing microconidia. This flask was accidentally broken and out of curiosity Massee examined a portion of the contents bearing microconidia. Two young perithecia were found which were almost colorless and without spores but bearing the long characteristic bristle-like, septate hyphae as did the mature perithecia found on the decayed cane. Two examples of the initial stage of a perithecium were found. The culture was placed under favorable conditions for the further growth of the perithecia, but unfortunately soon became covered with Penicillium and other growth, and gave no further results. However, from these results Massee concluded that he had the perfect stage of the fungus which he named *Trichosphaeria sacchari;* and as has already been stated he concluded this stage to be derived from the macrospore stage, which in turn arose from the Melanconium stage. The microspore formation was considered somewhat in the light of a variation of the macrospore formation, and like it to be derived from the Melanconium spores. It has already been shown that the genetic connection between the Melanconium stage and the macrospore and the microspore stages has not been demonstrated by Massee. It is equally clear that the finding of perithecia amidst macro- and microconidia on diseased cane and finding immature forms of some perithecia (possibly the same) on a culture of macro- and microconidia which are not demonstrated pure cultures does not prove or any more in the slightest degree suggest a gentic connection between the macro- and the microspores and these perithecia. Thus Massee has constructed the life history of the Melanconium fungus largely out of assumption.

It has been claimed in reference already quoted that *Melanconium* has a fourth stage in the life history, that of *Colletotrichum falcatum.* No work, however, was published to prove this assumption.

Went (39) in 1896 took up the matter of the relationship of the *Melanonium* with the macro- and microconidia. These two latter forms appeared to him to be identical with what he called *Thielaviopsis ethaceticus* and especially for that reason he wished to determine if there was any relationship between the various forms. Unfortunately the fungus with which Went worked does not correspond

to the West Indian *Melanconium*, so that the results cannot be taken as for or against Massee's claims.

In 1900 Howard (20) published a rather elaborate paper on his researches on this subject. He had already stated in another paper (21) that he had infected unsterilized pieces of cane with Melanconium spores and five days afterwards macro- and microconidia had developed. He found later, however, that a repetition of the experiment gave the macro- and the microspore forms as frequently on control canes as on inoculated canes. He thus concluded that the genetic connection between the various forms was *not* demonstrated. Howard further made many inoculation experiments both with the Melanconium form and with the macro-spores; he cultivated the macroconidial stages for over two years; and he had flask cultures under observation for 18 months, but in no case did he find Melanconium spores give rise to macroconidia or vice versa. He states that several thousand rotten canes were examined, but in no case did he find perithecia corresponding to Massee's *Trichosphaeria sacchari*.

From these various discussions it will be seen that no form other than the one originally described under the name of *Strumella* by Cooke has been proven for the *Melanconium*. There is the minor possible exception of chlamydospores found by Went with his questionable *Melanconium sacchari* but corroborated by Howard in flask cultures. So far as has been shown they have little bearing on the reproduction of the fungus as it actually occurs in the fields. Thus, so far as is known to-day, the life history of *Melanconium sacchari* is very simple, consisting only of the vegetative part producing stylospores, which in turn reproduce the plant.

ASSOCIATED FUNGI.

As has already been seen several fungi have been found associated with *Melanconium sacchari*, some of them so closely that they have been assumed to be stages of the same fungus.

Thielaviopsis ethaceticus.—The micro- and macrospores of *Melanconium* as described by Massee were believed to be identical with the spores of *Thielaviopsis ethaceticus* by Went. Howard was also of the same opinion. *Thielaviopsis* is not commonly found in standing cane, but is common in cut cane that has been left standing about or particularly in seed in the soil. *Melanconium* is characteristically found in standing cane. However, when affected seed is used the fruiting bodies of *Melanconium* may be found on seed in the soil.

Colletotrichum falcatum.—This was originally described by Went in Java as the cause of the red-rot or red smut. It is supposed to

gain entrance through borer holes or wounds in the cane, but does not usually fruit until the cane has dried out considerably. The fruiting bodies appear in velvety black patches on the dry part of the cane. Under a lens small black bristles are found to be abundant, and from among these arise the single-celled, colorless, more or less falcate spores. There is no evidence of pustule formation nor of any formation to mistake the *Colletotrichum* for the *Melanconium*.

Diplodia cacaoicola.—This fungus has been found on cane in India by Butler (3), in Barbados by Howard (22), and in Porto Rico by the author. A fungus was sent to Kew in 1878 from Porto Rico and was described in manuscript as *Darluca melaspora*. This was referred to by Cooke in Nuovo Gionale Bot., Vol. X, p. 26, 1878, who according to Massee (l. c.) incorrectly gave the locality as Australia. Saccardo changed the name to *Coniothyrium melasporum*, quoting Cooke's diagnosis incorrectly in Syll. Fung., Vol. III, No. 1799. Prilleux and Delacroix (31) in their paper on sugar-cane diseases have, according to Massee, wrongly considered *Melanconium sacchari* as synonymous with *Coniothyrium*. Examination of Berkeley's type specimen by Massee revealed the fact that it was a *Diplodia*. As already shown, however, on previous pages, Prilleux and Delacroix's description answers to that of *Melanconium* and not to *Diplodia*. When Massee examined the material he must either have seen another fungus or examined the wrong specimen. A fungus answering to the description of *Diplodia cacaoicola* occurs at present in Porto Rico on cane. This fungus forms pycnidia, which break through the rind in conical projections, thus resembling to some extent the eruptions of Melanconium. This fungus, however, has not been reported as common in any country, so that there is little danger of confusing it with *Melanconium*.

Cytospora sacchari.—This fungus has been reported by Butler (3), who states that it might be confused with *Melanconium*. It forms similar black eruptions on the surface of the rind. It has so far been reported only from India and from Porto Rico.

Melanconium saccharinum.—This fungus was originally reported from Java, but is common in Porto Rico, Santo Domingo and the Southern United States. Under certain conditions it might be mistaken for *M. sacchari*. This latter, besides occurring on the stalk, is abundant on the leaf sheaths and on that part of the leaf blades immediately adjoining the sheath proper. In these locations it seldom sends out the long threads, but usually appears as conical eruptions. Much the same appearance is presented by *M. saccharinum* and in the same part of the leaf. The two fungi may be present

at the same time. So far as is known *M. saccharinum* does not occur on the cane stalks, with the exception of the flowering stalk, and is not as yet known to cause serious damage.

Gnomonia iliau.—This fungus occurs in Hawaii and in Louisiana. The perfect or Gnomonia stage might at a casual glance be mistaken for *Melanconium sacchari*, but the necks of the perithecia are slender and hard and do not spread out as do the black spore masses of the rind fungus. The imperfect stage of *Gnomonia iliau* is called *Melanconium iliau* and to the writer does not present satisfactory means of identification to the naked eye, so closely does it resemble *M. sacchari.* Under a lens, or more especially under a compound microscope, the differences are readily apparent.

GEOGRAPHICAL DISTRIBUTION OF THE DISEASE.

United States.—The rind fungus (*Melanconium sacchari*) was reported by Dr. Stubbs in the Louisiana Planter for May 21, 1910. Edgerton (11) reported it as occurring only on seed cane. H. R. Fulton, formerly of the Louisiana Agricultural Experiment Station, sent to Washington specimens of *Melanconium sacchari* on cane. This was sent from New Orleans on October 19, 1907. About 1905 Dr. Erwin F. Smith was growing cane in the greenhouses in Washington, D. C., for studies on the gumming disease. On much of this cane *Melanconium sacchari* appeared. In the summers of 1911 and 1913 more cane was grown in other greenhouses in Washington, and on this cane appeared much of this disease. Further than these notes there are no records of the occurrence of this disease in the States, with the exception of the author's notes. These notes report its occurrence in Florida, Georgia, Louisiana, and Texas.

Cuba.—The fungus was reported as common on dead canes, leaf-sheaths and dead leaves that had been kept in a moist place and also as frequent on dead or injured parts of living canes, by Horne and Cooke (10). The writer has also seen this disease on standing cane at Nipe Bay, Cuba.

Jamaica.—As already mentioned, *Trululla sacchari* E&E identical with *Melanconium sacchari* was sent from Westmoreland County, Jamaica, and reported on by Cockerell (7) in 1891–93. Fawcett (15) in 1895 reported the rind disease due to *Melanconium sacchari* to be common on certain estates, especially in cane tops affected by the moth-borer.

Santo Domingo.—The author reported the rind fungus common in most of the cane districts of this Island in 1913.

Porto Rico.—Cane diseased by *Melanconium sacchari* was sent from Porto Rico to the United States Department of Agriculture in Washington in 1906 (?) and was identified by the writer. Tower (36) reported the fungus present especially on the south side of the Island. Fawcett (16) the following year reported it, stating that it was very common on the east end of the Island. In the report of the writer (23) for 1910–1911 the fungus is said to be prevalent all over the Island.

Barbados.—Bovell (2) reported in 1895 in regard to the rind fungus that "in many instances so badly has the disease attacked the canes that instead of an acre giving from two to three hogsheads of sugar it will require many acres to give one hogshead."

South (33) in 1909–1910 reported this fungus as always present on dead canes which are dry.

British Guiana.—Harrison and Jenman (18) stated that until early in 1894 the canes in British Guiana appeared to be quite free from fungoid disease, although the fungus *Trichosphaeria sacchari* could be found in greater or less abundance on dead canes and on the dead parts of dying canes in probably every field in the colony, but in February, 1894, they noticed that several varieties of seedlings were affected with rind fungus. Specimens of this fungus on cane were received from both Demerara and Essequibo.

Other English Colonies, in the West Indies.—Prof. Harrison (l. c.) visited Trinidad, St. Vincent, Barbados, Antigua, Grenada, and Carriacou and found the rind fungus present in all of them. South (l. c.) reported as follows:

St. Vincent.—The rind fungus occurred to a considerable extent, but chiefly in fields of the Bourbon variety of cane.

Antigua.—The fungus was not prevalent, but cases were somewhat more frequent than formerly. It was often noticed in fields badly attacked by root disease.

St. Kitts.—It was not observed to any extent.

Nevis.—It was observed on some estates. Seedling cane B147 was always more subject to attacks than any other variety.

Argentine.—Engler and Prantl (13) record *Melanconium sacchari* Massee on cane in Argentine.

Mauritius.—Prillieux and Delacroix (31) record the fungus in Mauritius. In an article entitled *La Maladie de la Canne* in *La Sucrerie Indigenie et Coloniale,* pp. 361–363, Vol. VII, 2d semester, 1894, is correspondence between Thistle-Dyer, of Kew, and M. W. Scott, of Mauritius, and discussion of the rind disease caused by

Melanconium sacchari. The Melanconium form was found to be very abundant. Massee records it from Mauritius in 1894.

British India.—Melanconium sacchari is stated by Butler (3) to be rare in British India. It is also reported from India by Massee (29). Barber (1) also records the fungus from India.

Tonquin.—The fungus was reported in this part of Indo-China by Prilleux and Delacroix (l. c.).

Java.—Went (38) describes its appearance in Java. His description in the Annals of Botany (39) is such, however, to lead one to suspect that he did not have the West Indian *Melanconium sacchari.* Thistleton-Dyer (35), in discussing the subject, thinks he had a very different fungus. Went describes black spherical conidia as being connected with the *Melanconium* with which he was working, and no one else has as yet published a description of such a form. He mentions chlamydospores, so that it cannot be certain just what Went had, although these were also found by Howard (20).

Natal.—Fuller (17) reported in this colony a fungus on sugar cane supposed by him to be *Strumella sacchari,* which, as we have seen, is identical with *Melanconium sacchari.*

Queensland.—The first description of *Strumella sacchari* was by Cooke (9) from a specimen received from Queensland. Tryon (37) also also records the occurrence of the rind disease in this country.

New South Wales.—Cobb (4) reported *Strumella sacchari* as occurring there.

Hawaii.—Perkins (30) in 1904 stated that "nearly a year ago, * * * an unusal outbreak of some parasitic leaf-fungi was noticed, and this was shortly followed by a similar spread of fungous diseases affecting other parts of the cane. It must not be supposed that these fungi are new to this country; they have been known to us for at least some years sporadically, but are now epidemic. The present epidemic is clearly due to the abundance of the leaf-hopper.

"At present by far the most widespread and injurious of these diseases is the so-called Rind Disease. * * *. On examining the stripped stem of young cane, I find that the fungus has already attacked this severely. * * * Whole fields of cane are simply saturated with the spores of the fungus."

Cobb (5) in 1906 stated that he had "noted the presence of rind disease in sufficient quantity to call for remedial action." Lewton-Brain (24) described the rind disease and the loss caused by it in 1907. Cobb (6), writing again in 1909, said that in many fields, especially ratoon fields of Lahaina cane, it was common to find the sheaths of the "*lalas*" (shoots from the top of the cane) attacked

by rind disease. "I have seen fields of this kind in which nearly every *lala* showed the spores of rind disease issuing from the sheaths of its lowest leaves, and when the higher leaves were pulled away it was evident that these, too, were attacked and in the first stages of the disease."

PARASITISM OF THE FUNGUS.

The fact that *Melanconium sacchari* has attracted such widespread notice would lead one to assume that it was without question a parasite. Still careful workers cannot accept the prevalence alone of an organism to indicate its parasitism. Though it may not in this case be an active parasite it is necessary at least to know its degree of parasitism before recommending methods of treatment.

A misleading idea given in many articles on fungous diseases is that the very presence of an organism to the apparent exclusion of others, or the preponderance of one organism over another indicates that it is the cause of whatever disease may be in the host plant. Thus the presence of *Melanconium* has been assumed by many to indicate that it was the cause of the diseased condition of whatever cane it might be found in.

Massee (27) was the first to publish the results of inoculation experiments with this fungus. His experiments were as follows:

Experiment I.—A sugar cane, 6 feet high and 1½ inch in diameter at the base, was inoculated by placing Melanconium conidia upon the base of an old leaf sheath, the leaf having fallen away. After twenty days the Melanconium fruit was fully developed, the long black filaments of conidia oozing out through minute cracks in the cuticle about half an inch above the node, and from the point of inoculation. At the same time as this experiment was made a small portion of diseased cane containing hyphae of the Melanconium stage was introduced into a slit made in the cane; this experiment resulted in the appearance of mature fruit bursting out from the cane after twenty-two days. The cane was cut down ten days after the last-mentioned experiment, and on being split open it was found that at the point where the inoculation was performed by wounding the cane the mycelium had produced the large macroconidia in the decaying tissue.

Experiment II.—Melanconium conidia were placed on moistened patches of young living leaves of sugar cane, some of the patches being first carefully washed to remove the bloom on the surface of the leaf, others not being so treated. After twelve days there were no signs of infection on the unbroken surfaces of young leaves and

stems, hence Massee concluded that while *Melanconium* was a parasite it was only a wound parasite. In his own words he demonstrated conclusively that the fungus called *Trichosphaeria sacchari* (the Melanconium stage) can effect an entrance into healthy tissue quite independently of the agency of "shot-borer" or "moth-borer."

"Although a true parasite, in the sense of destroying perfectly healthy tissues, the fungus almost invariably commences as a saprophyte."

Besides Massee, Went made inoculation experiments to demonstrate the parasitism of this fungus. As before remarked, however, we cannot be certain that the *Melanconium* with which he worked is identical with that of the West Indies. With the fungus with which he was dealing he made inoculations into slits made into sound canes; the mycelium developed in the cells surrounding the slits, but in no case (9 experiments) did it attack the healthy tissue of the cane. Later he sterilized pieces of sugar cane by keeping them in a flame for some time; he then divided them longitudinally with a sterilized knife and placed them in a sterilized glass box. On the cut surface he placed some of his Melanconium spores, but out of ten experiments only three finally showed pycnidia, and this was on dying cane. Thus Went does not consider *Melanconium,* or whatever fungus he was working with, to be parasitic.

So far as publications show Howard has been the only other one to test the parasitism of the rind fungus. He published a report (21) of his experiments in 1900, in which he split open healthy unsterilized canes and inoculated them with Melanconium spores, and with mycelium developed from a pure culture. Five days afterwards both micro- and macroconidia developed. Later, however, Howard (20) decided that these micro- and macroconidia had no genetic connection with the Melanconium spores, as they appeared as frequently on control canes as on the inoculated ones. In his early experiments he had concluded that *Melanconium* was parasitic as some infection had resulted. As the infection did not spread, however, more than three inches above and below in three months' time, and as the canes showed none of the typical appearance of the disease he concluded to repeat the experiment. The results are set forth in the last publication cited.

Experiment I.—On November 27 eighteen healthy Bourbon canes were selected, of which six were used as controls and twelve for inoculation at wounds, six with Melanconium spores from a pure culture and six with similar spores and food material. The places where the wounds were made were cleaned with alcohol and flamed with a spirit

lamp. The holes were cut with a sterile knife, and after being inoculated were bound up with sterilized tape which had been soaked in parafin. The control canes were treated in a similar manner, but in this case no spores were introduced. On Decmeber 28 these canes were examined. In no instance had the mycelium spread to any extent, except immediately above and below the wound where it had reached the nearest nodes. The affected tissues were a bright red, but the cane exhibited no traces of the rind disease. The controls showed no infection, although the cells around the wound were bright red and the bundles cut through showed gumming in the large vessels.

Experiment II.—On December 10 four healthy White Transparent canes were inoculated with Melanconium spores from a pure culture at wounds made with a sterile knife as before. Four other canes from the same stool were used as controls. Thirty days afterwards the canes were examined. In all cases the tissues were brownish red above and below the wounds, but no difference was evident between the inoculated canes and the controls in this respect. On examining the inoculated canes it was found that the mycelium of the fungus had in all cases spread in the tissues immediately above and below the wounds as far as the nearest nodes, but it could not be traced beyond the vertical column of tissue containing the wound and bounded by the nodes above and below this aperture.

Experiment III.—On December 19 four healthy White Transparent canes were doubly inoculated—at wounds in an upper and a lower internode—with actively growing mycelium of the fungus from pure cultures. Four other canes were used as controls. On January 22 the results were almost identical with those obtained above.

Experiment IV.—The same experiment was made using only spores from a pure culture instead of the mycelium. The same results were obtained.

Howard concluded as a result of his studies that *Melanconium* cannot be considered as the cause of the "rind" disease. He appears to have shown that *Melanconium* is not an active parasite, but it is not clear that he has demonstrated this fungus to be only a saprophyte. In fact his inoculations rather point to *Melanconium* being a wound parasite. Howard appears to be assuming that the rind disease is caused by an active parasite, for the proof of which he presents no facts whatever.

CAUSE OF THE RIND DISEASE.

In discussing the cause of the rind disease it will be well to review briefly the symptoms of this trouble first. As mentioned in

an early part of this paper the rind fungus is one causing numerous tiny black eruptions from the rind or epidermis of the cane stalk. From first to last there has been only one fungus found in these typical eruptions. It was first called *Strumella sacchari* and later *Melanconium sacchari,* the name under which the fungus is known at present. As to the secondary symptoms it is very difficult to judge for the reason that usually insects, other fungi or unsatisfactory growth conditions are present to complicate the matter. In cane affected with the rind disease the leaves begin to wither and dry up. Often a rotten top is found. Frequently there is a reddening of the stem. Now as to which of these symptoms are connected with the rind disease no one has as yet attempted to make an analysis. That being the case we have only the eruptions of the rind for a certain characteristic of this disease. From these only *Melanconium* has been isolated, absolutely no other fungus. How then can we conceive of some other fungus as the cause of these symptoms? It is manifestly impossible. That Howard failed to obtain successful inoculations is not to the point. There has been no work done to show that *Melanconium sacchari* was not the cause of the eruptions of the rind of the cane.

Now Howard has approached the subject from an entirely different point of view. He has selected certain symptoms of disease in the plant, isolated fungi from the diseased parts, inoculated pure cultures of the fungus into healthy tissues and obtained the same symptoms of disease, and has then concluded that the fungus he is dealing with is the cause of the rind disease, disregarding the fact that neither the symptoms nor the fungus have much to do with the rind and have nothing whatever to do with the eruptions on the rind. The symptoms of the rind disease as he gave them are the drying of the leaves, which commences at the margins of the older ones and gradually spreads to the center of the bunch in from four to six weeks. As soon as this drying of the leaves is well marked, the stem of the cane shows a brown discoloration in one or more places, after which the rind shrivels up and the discoloration rapidly extends in all directions. On splitting such canes the tissues are seen to be of a general reddish color, in which darker red areas can be seen. Very frequently these darker regions contain definite white centers elliptical in vertical section. He states that the appearance is exactly like that figured by Went for the Red Smut due to *Colletotrichum falcatum.* Howard isolated this fungus and made successful inoculations and thus concluded that the rind disease was due to *Colletotrichum falcatum.*

It is unfortunate, to say the least, that the matter of the cause of the rind disease should be further involved by confusing the symptoms. Howard is here dealing with an entirely different fungus and entirely different symptoms from those which characterize the rind disease.

As has been shown neither Howard nor Massee nor any other worker succeeded in getting good pure culture inoculations of *Melanconium sacchari*. On the other hand, no one has found any other fungus than *Melanconium sacchari* associated with the typical conditions of the disease, *i. e.*, the eruptions of the rind. Until more is done, therefore, to prove the contrary, *Melanconium sacchari* should be considered as the cause of the rind disease.

NATURAL INFECTION OF STALK, LEAVES AND CUTTINGS.

Whatever question there may be about the active parasitism of the rind fungus, there can be no question as to the actual occurrence of the fungus on the cane in the field. The following is in part a repetition of what has gone before, but taken altogether it will serve to summarize the conditions.

OCCURRENCE ON THE STALKS.

Melanconium sacchari commonly occurs on green cane stalks at such points of injury as those caused by the weevil borer, near the base of the stalk. These injuries are not sufficient to kill the stalk and it remains green until infected by the rind fungus, and even then the infection progresses only according to the vigor of the cane. The fungus occurs at similar points of injury caused by the moth stalk-borer which may occur any where along the stalk, perhaps more commonly near the top. The moth borer or some bud moth often gets into the top of the cane and kills the heart. This injury is usually succeeded by an infection of the rind fungus which progresses downward. Occasionally the top is rotted and a Melanconium infection is present without any sign of insect injury. The extent of all this damage depends largely upon the vigor of the cane as discussed elsewhere.

OCCURRENCE ON LEAVES.

A point that apparently has not been considered of great importance is the occurrence of this fungus at the base of leaf-sheaths and occasionally near the joint of the sheath and blade. This occurrence is very common in cane over 8 or 10 months old. It has not been proven to be the same as the stalk fungus, but it cannot be

separated from it morphologically. It would seem to the writer that this point is of considerable value, for it may be assumed that so long as the fungus is present in the field anywhere, either on the leaf-sheaths or elsewhere, that there is a possibility of some damage whenever the right conditions for it occur. There is some variation in the different varieties of cane so far as apparent susceptibility is concerned, and observations have been made on over 50 varieties. However, the occurrence of the fungus does not seem to be constant so that up to the present it is not possible to state definitely that certain varieties are more immune than others. In general the softer varieties such as T77 are more commonly infected on the leaves than such as D116.

OCCURRENCE ON CANE CUTTINGS.

Very commonly cuttings that have failed to germinate have been dug up and found infected with this fungus, apparently killed by it.

On one occasion several sacks of cuttings were kept for a period of five weeks. When they had been cut they were supposed to be free from disease, but examination at the end of the five weeks showed that out of 156 cuttings, 135 had the rind fungus, and of these 135, 71 had the rind fungus and no other.

LOSS DUE TO THE RIND FUNGUS.

In a disease of this kind it is impossible to state definitely the amount of loss caused. The injury is usually associated with that due to other causes, and it is impossible to consider them apart. One may say that a certain field of cane is entirely destroyed by the rind fungus, whereas the rind fungus might not have infected the cane in the first place if it had not suffered from root disease, drought, moth-borer injury or any one of several factors. It is also just as true that one may say that the same field was entirely destroyed by any one of these factors, where as a matter of fact the loss would not have been half so great without the rind fungus. In general terms I would state that the loss due directly to the rind fungus is often very heavy, involving a partial or complete loss of hundreds of acres of cane in some seasons.

TREATMENT OF THE DISEASE.

It is sometimes unsafe to make recommendations for the treatment of a certain disease when the cause or nature of the disease is not well understood. If the recommendations are restricted to general

improved methods of cultivating the cane or of handling it, however, they may be valuable. Such has usually been the type of advice given by various investigators when working on this disease.

In 1895 there was published in the Kew Bulletin an article on sugar-cane disease in Barbados and extracts were included from the report of the commissioners appointed by the Governor of Barbados to inquire into the pests and diseases of the cane. This commission made the following recommendations:

That all plants be soaked in Queensland solution[1] before planting.

That whenever deemed possible by the inspector the practice of spreading trash around young canes be given up; and that whenever it be resorted to, only trash from a field which had been inspected and declared healthy or as healthy as possible be employed.

That rotten canes on all fields diseased with rind disease should be burnt on the field, or crushed and burned as mentioned below.

That rotten canes on all fields be regularly burned during the crop. Juicy canes could be first crushed and the megass burned, the juice being boiled.

That the trash used as litter be taken from fields which are healthy or as healthy as can be got.

That each estate put such an area under the so-called hardy varieties of cane plants as will suffice to replant the whole of the estate in those varieties if necessary.

That the cane fields be periodically inspected, with a view to cutting out the canes infected with borer or fungus, which canes should be bagged upon the spot and taken away, crushed and burned.

Fawcett, writing in the same year (1895) in the Bulletin of the Botanical Department of Jamaica, adds to the foregoing recommendations the following:

Only healthy tops of strong canes should be used as seed canes.

To avoid any chance of the fungus existing unnoticed in the tops, they might be steeped in a solution of sulphate of iron (one ounce powdered in three gallons of water) for a few hours, especially if they are pierced by the borers.

Unfortunately no report of experiments is available to show the value of this latter suggestion. The idea of the sulphate of iron is purely as a disinfectant, which is well accomplished by the use of Bordeaux mixture. Moreover, it should be noted that the mycelium of the rind disease may be within the stalk as well as at the surface, and if there is any of the mycelium within, soaking in any mixture long enough to kill the fungus growth within will also injure the cane. Dipping seed in sterilizing mixtures is purely for the purpose of destroying external fungi and providing a protective covering to prevent the entrance of fungi.

[1] Queensland solution equals one pint of carbolic acid to 100 gallons of water.

ALLIED FUNGI.

This subject has already been discussed so far as other alleged stages of this fungus are concerned. The claim that *Trichosphaeria sacchari* is the perfect stage of *Melanconium sacchari* has been shown to be without sufficient proof. The so-called microconidia and macroconidia of *Melanconium* have been shown to be in all probability the same as *Thielaviopsis ethaceticus*, apparently an entirely different fungus.

Other species of *Melanconium* have been described, among which are the following:

Melanconium saccharinum Penz et Sacc. in Malphigia, 1901, p. 238; Ic. Fung. Jav. t. LXV, f. 3.—Acervulis hypophyllis, gregariis, longitrosum seriatis oblongis, 1 mm. long., 0.5 lat., nigris, epidermide hysteriodes-rimosa velatis; conidiis majusculis globoso-compressis e fronte 24 microns latis, e latere 14 microne cs., nigrantibus, levibus, hyphulis filiformibus tenerrimis, hyalinis suffultis. Sacchari officinarum prope Buitenzorg, in insula Java.—affine *M. bambusino* et *M. hysterino*, sed satis diversum videtur. (from Saccardo.)

Melanconium iliau Lyon described in a Study of Iliau by H. L. Lyon in Hawaiian Sugar Planters' Record and by Edgerton. This fungus is so described as to be in all grosser appearances exactly similar to *Melanconium sacchari*. Its method of fruiting is exactly the same, but the spores are very different. They are large and filled with spherical granules, measuring 7–10 x 15–28 mu.

SUMMARY.

1. The symptoms of the rind disease are the eruptions on the rind of the cane from which protrude black masses of spores, together with a drying up of the leaves.

2. The disease has been studied for the last twenty years at least in various parts of the world.

3. The fungus causing the rind disease has only one known spore form in its life history.

4. The rind fungus occurs in the Southern United States, all through the West Indies and Demerara; in Natal, Mauritius, British India, Java (?), Australia, and Hawaii.

5. The fungus is what is known as a wound parasite, *i. e.*, capable of infecting cane only through wounds, or cane that is in an otherwise unhealthy condition. It may be classed as an active parasite on certain weak or soft canes such as Bourbon and D116.

6. The rind disease is caused by *Melanconium sacchari*, one of the fungi imperfecti.

7. Treatment of the disease is restricted to the use of hardy varieties, to adopting such methods as will reduce the moth borer, and to grinding the cane before it is overripe.

8. *Melanconium saccharinum* and *M. iliau* have also been described on cane, but are not to be considered as causes of the rind disease.

9. The rind disease is common in Porto Rico.

BIBLIOGRAPHY.

1. Barber, C. A.—Sugar cane in the Godavari and Ganjari districts. Dept. of Land Records and Agric., Madras. Vol. II, No. 43, 1901.

2. Bovell, John R.—Report on the sugar-cane fungus (Trichosphaeria sacchari) at present existing in the Island. In sugar-cane disease in Barbados Kew Bull. Nos. 100–101, 1895.

3. Butler, E. J.—Fungous Diseases of Sugar Cane in Bengal. Bot. Ser. Vol. I, No. 3, July, 1906. Memoirs of the Dept. of Agric. in India.

4. Cobb, N. A.—Agric. Gaz.. New South Wales. Vol. IV, pl. 10, pp. 777–857, 1893.

5. Cobb, N. A.—Fungus Maladies of the Sugar Cane. Bul. No. 5, Haw. Sugar Planters' Asso., 1906, 106–110.

6. Cobb, N. A.—Fungus Maladies of the Sugar Cane. Bul. No. 6, Haw. Sugar Planters' Asso., 1909, p. 39–40.

7. Cockerell, T. D. A.—A New Fungus on Sugar Cane. Journ. Insti. Jam. Vol. I, 1891–1893, p. 159.

8. Cooke, in *Nuovo Giornale Botanico. Italiano,* 1878, Vol. X, p. 26.

9. Cooke, in Grevillea, Vol. XIX, p. 45.

10. Cooke, M. T., and Horne, W. T.—Insects and Diseases of Corn, Sugar Cane, and Related Plants. Bul. 7, May, 1907, p. 25. *Estación Centr. Agron. de Cuba.*

11. Edgerton, C. W.—Some Sugar-cane Diseases. Bul. No. 120, La. Agric. Expt. Sta., July, 1910, p. 16.

12. Edgerton, C. W.—The Stem Rot or Hawaiian "*Iliau*" Disease of Sugar Cane. Phytopathology, Vol. III, No. 2, April, 1913, pp. 93–97, pl. 7.

13. Engler & Prantl.—*Die Naturlichen Pflanzenfamilien.* Fungi, Vol. I, pt. 1, pp. 403–5.

14. Fawcett, W.—Disease Among Sugar Cane. Bul. Bot. Dept. Jam. n. s. Vol. II, 1894, pp. 57–59.

15. Fawcett, W.—Report on Disease in Sugar Cane. Bul. Bot. Dept. Jam. n. s. Vol. II, No. 8, pp. 165–167, 1895.

16. Fawcett, G. L.—Report of the Plant Pathologist, An. Rept. of the P. R. Agric. Expt. Sta. for 1908, pp. 34–5, 1908.

17. Fuller, C.—Sec. Rept. of the Govt. Entom. Natal Dept. Agric., 1901, pp. 72, pls. 3, figs. 23.

18. Harrison, J. B., and Jenman, G. S.—Sugar-cane Diseases. In report of the agricultural work in the bot. gardens for the years 1893–4–5. Brit. Guiana, 1897, pp. 98–104.

19. Howard, A.—The Rind Disease of Sugar Cane in the West Indies. Intern. Sugar Journ. Vol. V, 1903, No. 53, pp. 215–225, pl. 1.

20. Howard, A.—On Some Diseases of Sugar Cane in the West Indies. Annals of Bot. Vol. XVII, p. 373–412, 1903.

21. Howard, A.—On Trichosphaeria sacchari Mass. Annals of Bot. Vol. XIV, pp. 617–631, 1900.

22. Howard, A.—Diplodia Cacaoicola, a Parasitic Fungus on Sugar Sane and Cacao in the West Indies. Annals of Bot. Vol. XV, No. 60, pp. 683–701, 1901.

23. Johnston, J. R.—First Report of the Pathologist. Yearbook of the P. R. Sugar Growers' Asso., year 1910–11, pp. 61–74.

24. Lewton-Brain, L.—Rind Disease of the Sugar Cane. Bul. 7, Haw. Sugar Planters' Asso., 1907.

25. Lyon, H. L.—A Study of Iliau. The Hawaiian Planters' Record, Vol. III, No. 3, Sept., 1910, pp. 143–153.

26. Massee, G.—Kew Bull. July, 1893.

27. Massee, G.—On Trichosphaeria sacchari, Mass. Annals of Bot. Vol. 7, 1893, pp. 515–532.

28. Massee, G.—Sugar-cane Disease in Barbados. Kew Bul., Nos. 100–101, 1895.

29. Massee, G.—Sugar-cane Diseases in the Old World. Kew Bul., p. 81, 1894.

30. Perkins, R. C. L.—On some diseases of sugar cane specially considered in relation to the leaf-hopper pest, and to the stripping of the cane. The Hawaiian Forester and Agriculturist. Vol. I, No. 4, 1904, pp. 80–84.

31. Prilleux and Delacroix.—*Sur une maladie de la canne a sucre produite par le Coniothyrium melasporum (Berk.) Sacc. Bul. Soc. Myc. de France,* Vol. XI, p. 75, 1895.

32. Saccardo, Syll. Fung. Vol. III, No. 1799.

33. South, F. W.—Report on the prevalence of some pests and diseases in the West Indies, for the year 1909–1910. W. I. Bul. Vol. XI, No. 2, pp. 74–75, 1911.

34. Thistleton-Dyer, W.—Sugar-cane Disease in Barbados. Kew Bul., Nos. 100–101, 1895, pp. 84–88.

35. Thistleton-Dyer, W.—Note on the Sugar-cane Disease of the West Indies. Annals of Bot. Vol. XIV, 1900, pp. 609–616.

36. Tower, W. V.—Rept. of the Entom. and Path., An. Rept. of the P. R. Expt. Sta. for 1907, May 4, 1908, p. 37.

37. Tryon, H.—Some Obstacles to the Successful Cultivation of Cane. Queensland Agric. Journ. Vol. IX, p. 85, 1901.

38. Went, F. A. F. C.—On the Appearance of the West Indian Rind Fungus in Java. Med. Proef. Sta., West Java. No. 23, pp. 6–12.

39. Went, F. A. F. C.—Notes on Sugar-cane Diseases. Annals of Bot. Vol. X, pp. 585–609.

PLATE I.

Stalks of cane severely attacked by rind disease, showing the characteristic black fruiting pustules.